

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matter of

Amendment of the Commission's Rules with
Regard to Commercial Operations in the
3550-3650 MHz Band

GN Docket No. 12-354

COMMENTS OF GOOGLE INC.

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February 20, 2013

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I. INTRODUCTION AND SUMMARY.

The goal of this proceeding is to encourage new uses of the 3.5 GHz band for fixed and mobile broadband, while protecting localized incumbent operations. Providing wireless broadband access in the 3.5 GHz band presents manufacturers and service providers with significant technical and economic obstacles. Developing these frequencies into a commercially viable band will be challenging.

To support robust use of the 3.5 GHz band, therefore, the Federal Communications Commission should adopt rules that permit a variety of business models, assure access for entities that build facilities, and avoid unnecessary regulation or technical complexity. If rules are any more rigid than absolutely necessary to protect incumbents, or if interference avoidance mechanisms and registration eligibility determinations are too complex and burdensome, service providers and manufacturers will not invest in the 3.5 GHz band. The Commission's primary objective, accordingly, should be to design use and interference-protection rules that will encourage development of the band.

To achieve this goal, Google suggests that the Commission should:

- Implement a three-tier access system with an incumbent tier, a “priority” or “secondary exclusive” access tier¹ with broad eligibility and a substantial service requirement, and a general authorized access (“GAA”) tier.
- Ensure the widest possible market for new products and services by establishing reasonable technical specifications for commercial operations in the band and allowing small cell operations both outdoors and in the adjacent 3650-3700 MHz band.

¹ The Commission refers to this tier as “priority access.” Google suggests that the term “secondary exclusive access,” coined for this purpose by the President’s Council of Advisors on Science and Technology (“PCAST”), more accurately describes the type of use that will meet the FCC’s goals for this tier. All references to “secondary exclusive” use in these comments refer to this service tier, which protects existing incumbent uses in the 3.5 GHz band, but receives protection from other secondary uses and from GAA uses.

- Calculate exclusion zones: (1) to protect against the risk of interference new entrants pose to incumbent operations rather than against the risk incumbent operations pose to new entrants; and (2) based on the decreased risk of interference to incumbents from small cell operations as compared to the risk related to the macrocell network assumed by NTIA.
- Rely on a robust Spectrum Access System (“SAS”) administered by commercial entities with a set of capabilities that protect incumbent operations and allow mutual protection among secondary exclusive users.

By adopting rules consistent with these principles, the Commission will not only attract innovators and investors to the 3.5 GHz band, but also establish the band as a model for further spectrum sharing in other government bands in the United States and around the world.

II. THE COMMISSION SHOULD ADOPT A 3.5 GHz LICENSING FRAMEWORK THAT MAXIMIZES EFFICIENT USE OF THE BAND.

The Commission should not dictate technologies in the 3.5 GHz band. Nevertheless, both the Notice of Proposed Rulemaking in this proceeding and last summer’s report issued by the President’s Council of Advisors on Science and Technology correctly found that the 3.5 GHz band is well suited for small cell use governed by a geographic sharing mechanism.² The characteristics of the 3.5 GHz band—including relatively poor signal propagation and “highly localized” incumbent uses³—mean that a spectrum access system for small cell applications, using a geolocation-enabled database system, can “allow disparate radio systems to operate in closer proximity...enabl[ing] greater sharing opportunities with incumbent systems” as well as

² See generally *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Notice of Proposed Rulemaking and Order, GN Docket No. 12-354 (rel. Dec. 12, 2012) (“NPRM”); Executive Office of the President, President’s Council of Advisors on Science and Technology, *Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, Report to the President (July 2012) (“PCAST Spectrum Report”).

³ NPRM ¶¶ 5, 19.

with other commercial systems.⁴ This sharing, in turn, will provide expanded access to a range of new wireless broadband services⁵ by enabling users to access the band according to their priority level and the availability of frequencies.⁶ Successful deployments in the 3.5 GHz band will also enable this band to serve as a model for dynamic sharing opportunities in other spectrum bands.

The three-tier access model proposed in the PCAST Spectrum Report and the NPRM will allow the Commission to maximize use of, and innovation in, the 3.5 GHz band. It will protect incumbents, ensure secondary exclusive use for those with a need for uninterrupted access to quality-of-service-dependent applications, and permit innovative, opportunistic access where 3.5 GHz spectrum is not otherwise in use. Google further recommends that the FCC: (1) ensure that this three-tier system creates a balance between those users with a need for certainty (secondary exclusive users) and those users with more flexibility (GAA users), and (2) allow GAA use of 3.5 GHz frequencies wherever incumbent and priority users are not operating.

A. The Secondary Exclusive Access Tier Should Promote Efficient Spectrum Use by Establishing Broad Eligibility to Deploy Networks Managed by the SAS.

1. Eligibility.

The Commission contemplates creating a secondary exclusive tier that grants access to a portion of the band to a defined set of users, while reserving another portion of the band for GAA users.⁷ Google agrees that tiered rights of access will accommodate diverse uses and make

⁴ *Id.* ¶¶ 19-21.

⁵ *Id.* ¶¶ 5, 6, 19.

⁶ *Id.* ¶ 58.

⁷ *Id.* ¶¶ 72, 76.

the 3.5 GHz band attractive for more investors and network builders. However, the Commission should not limit eligibility for the secondary exclusive access tier only to uses and users that the FCC classifies as “critical” by some measure. Doing so would undermine the Commission’s goal of bringing mass-market, commercial-scale technologies to the 3.5 GHz band. The Commission should instead encourage widespread deployment of systems that require reliable access to spectrum to deliver a higher quality of service by opening the secondary exclusive tier to any applicant that commits to a substantial service requirement.

In the 3.5 GHz band, the FCC can both maximize spectrum access and avoid mutually exclusive applications, consistent with Section 309(j) of the Communications Act, by permitting secondary exclusive operations: (1) in limited geographic areas, (2) for limited periods of time, (3) on a first-come, first-served or other priority basis, (4) subject to physics-based interference determinations, and (5) conditioned on quickly meeting a substantial service requirement.⁸ This open-eligibility approach is preferable to attempting to limit eligibility to certain industries the Commission perceives at this time as having “a distinct need for reliable, prioritized access to broadband spectrum.”⁹ It allows actual market experience, rather than regulatory prediction or preference, to pick the most valuable uses and technologies. An alternative approach, in which

⁸ As the Commission considers mechanisms for avoiding mutual exclusivity, it should recognize that a sufficiently sophisticated SAS will not only ensure that incumbent users are protected, but also maximize spectrum utilization while accommodating secondary exclusive users. By combining terrain- and physics-based propagation modeling with modern self-organizing network (“SoN”) mechanisms that include network listen and measurements from mobile terminals, an SAS has great visibility into network operations. A physics-based interference calculation and protection approach will also create a scalable and reliable framework for mutual protection among secondary exclusive users regardless of their location. These features, along with dynamic spectrum allocation and the substantial service requirements described below, will ensure that commercial deployments in the 3.5 GHz band make highly efficient use of this spectrum.

⁹ NPRM ¶ 9.

the Commission assigns spectrum rights in the 3.5 GHz band by auction, would dramatically raise the barriers to entry and costs of operating in an already difficult band—thus reducing innovation and intensive sharing of the band.

Attempting to base eligibility on real property ownership, as the Commission alternatively has suggested, would impede entry into the secondary exclusive tier by users building integrated indoor/outdoor networks. These are the users that will drive a sustainable and economic device ecosystem, have the largest capacity and coverage needs, and most require the quality of service secondary exclusive access can provide. Such a restriction would require potential users to authenticate and coordinate permission from thousands of property owners, their assignees, or agents for operations in a particular area, and at best would substantially increase the costs of establishing widespread operations in the band. Importantly, this process could not be automated through the SAS. Users would have to contact and negotiate with property owners one by one. This would undermine the Commission’s goal of using the SAS to reduce transactions costs for spectrum access in the band, potentially increasing costs to the point where use of the band is not economic.

Furthermore, many residential buildings are owned in shares by unit owners or residents. These ownership structures may not have an effective common administrative mechanism capable of making a usage determination regarding “air rights.” Even the threshold question of ownership is likely to be complex where a single building is owned by multiple parties. Operations in geographic areas that span numerous properties—which will be common in densely populated areas—only compound these problems.

2. Geographic Areas.

The Commission contemplates accommodating secondary exclusive access through geographic “Priority Use Zones” where incumbent operations are unlikely to interfere with, or receive interference from, commercial users.¹⁰ Under this proposal, the FCC would allow users to reserve secondary exclusive frequencies “in a given location...only while [secondary exclusive] users are actually operating.”¹¹

Google supports this proposal. The Commission should establish rules that permit dynamically sized, limited reservation areas by enabling the SAS to assign locations that are only as big as needed for a particular cell site (taking into account likely small cell use), including the transmit power levels recommended below.¹² Such a system will: (1) capture the benefits of high spectrum reuse, (2) minimize conflicts among potential users, and (3) maximize opportunities for secondary exclusive users to provide robust and reliable wireless broadband services. Given the relatively low power levels typically used by small cell deployments, Google anticipates that each geographic area reservation will be limited in size—on the order of a city neighborhood rather than a city. Moreover, although the Commission should permit a secondary access user to register multiple cell locations, a registrant should separately comply with Commission rules, including substantial service obligations, with regard to each location it reserves.

¹⁰ *Id.* ¶ 70.

¹¹ *Id.* ¶ 72.

¹² *See id.* (“Through use of the SAS and any other mitigation strategies that are ultimately adopted in this proceeding (including maximum transmitter power levels, limits on in-band and out-of-band emissions, flexible and resilient spectrum sharing technologies, and contention protocols), we anticipate that Priority Access users would be able to deliver a variety of consistent, high quality wireless broadband services to their users.”).

3. Band Plan and Channelization.

The Commission seeks comment on its proposal to allow secondary exclusive use in 50 MHz of the 3.5 GHz band, as well as whether it should consider establishing specific frequencies for secondary exclusive operations.¹³ As a general matter, the 3.5 GHz rules should not uniformly and statically divide spectrum between secondary exclusive services and GAA users. Rather, a sophisticated SAS should dynamically assign spectrum as needed on a location-by-location basis.

This approach is fully compatible with the goal of ensuring quality of service for secondary exclusive operations. For example, it is foreseeable that multiple secondary exclusive operators will want to establish networks in adjoining areas. Depending on the operating environment, the SAS may be able to guarantee sufficient quality of service on a co-channel basis, as would be the case if there is sufficient geographic separation between the networks or the terrain provides sufficient signal attenuation. In other cases, however, the SAS may not be able to guarantee quality of service, and would instead assign separate channels to the operators, who would use the assigned spectrum optimally within their network.

Because the SAS will determine the amount of spectrum available for secondary exclusive use in a given area, this process necessarily means that the SAS will likewise determine the remaining spectrum available for GAA operations in that area. The Commission should, in addition, establish rules under which the SAS would reserve some spectrum specifically for GAA operations as necessary to ensure that GAA devices can operate even in geographic areas where demand for secondary exclusive spectrum is high.

¹³ *Id.* ¶ 74.

The Commission also asks whether it should establish sizes for channels and whether those channels should be paired or unpaired.¹⁴ Because there are challenges involved in efficiently pairing channels in the 3.5 GHz band, Google anticipates that the dominant usage scenario for secondary exclusive use will be time-division duplex (“TDD”) operations. Accordingly, secondary exclusive channels need not be paired.

In frequency division duplex (“FDD”) networks using paired spectrum, base stations pose an interference risk to other base stations, while transmissions from mobile devices pose an interference risk to other mobile devices. In contrast, in an unsynchronized TDD network, a base station transmission can interfere with a much weaker transmission from a mobile device. Accordingly, TDD infrastructure elements are typically synchronized in time to ensure co-channel operation and maximization of spectral efficiency. Synchronizing multiple separate entities operating within the same vicinity will increase the likelihood that these entities will operate harmoniously with each other. Google therefore recommends that the SAS provide a timing reference to achieve time synchronization.¹⁵

With respect to channel size, Google recommends that the Commission define channels of at least 20 MHz. These wider channels offer higher statistical multiplexing efficiency, as devices are able to complete bursty transmissions in a shorter duration of time. 20 MHz TDD channels coupled with a lack of static partitioning between secondary exclusive and GAA users will ensure a robust mobile broadband experience.

¹⁴ *Id.*

¹⁵ There are a number of mechanisms to ensure time synchronization, including: (i) GPS; (ii) listening to known macrocell transmissions (which are, in turn, GPS synchronized); (iii) television transmissions; and (iv) IEEE 1588 packet time protocol synchronization mechanisms. The SAS and secondary exclusive infrastructure entities could use a combination of these techniques to achieve time synchronization.

4. Widespread Use.

A core recommendation in the PCAST Spectrum Report is that spectrum should be assigned for use rather than *non-use*. To be sure, an entity seeking to provide secondary exclusive services should be able to know in advance that it will have access to spectrum at locations where it is planning to deploy service. However, the Commission's rules also must include meaningful disincentives to hoarding spectrum. The Commission should balance these interests by requiring registered secondary exclusive users to provide substantial service within six months of reserving spectrum. If they fail to do so, then they should be ineligible for additional reservations of secondary exclusive spectrum in that geographic area for one year. Alternatively, secondary exclusive users that fail to meet their service requirement could permanently lose reservation rights within the given geographic area. Implementing a substantial service requirement ensures that spectrum is put into use as quickly as possible and that, if a registrant does not deploy service, spectrum resources will be made available to another user that will.

In addition, until a registered secondary exclusive user actually begins providing service, frequencies in the geographic area where it intends to operate should be available for GAA use. Under the Commission's proposal, GAA devices will "rely on the [SAS] database to identify available spectrum on a real time or near real time basis,"¹⁶ and GAA devices will be expected to "query the SAS anytime a device is activated, when a device is moved, or at some set time interval."¹⁷ These requirements will ensure that when a secondary exclusive network is ready to enter service, the SAS will reflect that any frequencies used by GAA devices are no longer

¹⁶ NPRM ¶ 101.

¹⁷ *Id.* ¶ 102.

available and must be vacated. In the interim, however, GAA users can access valuable spectrum for beneficial use.¹⁸

B. The GAA Tier Should Promote Efficient Spectrum Use by Enabling Widespread Opportunistic Use in Areas Where There Are No Incumbent or Secondary Exclusive Operations.

The Commission's proposal contemplates that certain geographic areas will not be designated for secondary exclusive use in order to protect incumbent users from interference, and that in those areas, non-interfering GAA devices may operate across the entire 3.5 GHz band.¹⁹ Google supports this proposal and, more generally, believes that the Commission's rules should permit widespread opportunistic use by GAA devices. The proposed geolocation-enabled dynamic database will permit GAA devices to access available spectrum at a particular location, without interfering with existing incumbent (or secondary exclusive) uses. To enable GAA use by portable devices, the Commission's rules should require communication with the SAS database whenever a device moves more than 500 meters.

In addition, the Commission's rules should require GAA devices to vacate frequencies that will be used by incumbents or secondary exclusive networks as soon as those services are ready to commence new operations. Accordingly, the Commission should ensure that its rules require GAA devices to query the SAS at appropriate intervals so that they can properly account for prospective deployments.

¹⁸ Similarly, if a secondary exclusive user decides to stop service during the pendency of its right to exclusive use, these frequencies should be made available for GAA users as soon as service ceases. Furthermore, as described below, registration for secondary exclusive users should be open and transparent. This approach will allow parties to verify whether a registered user is actually using reserved spectrum, and would allow the Commission to consider mechanisms for giving other users incentives to identify when secondary exclusive users are not providing service.

¹⁹ NPRM ¶ 76.

III. THE COMMISSION SHOULD ADOPT OPERATING RULES FOR THE 3.5 GHz BAND THAT BOTH PROTECT INCUMBENT OPERATIONS AND SUPPORT INVESTMENT.

Operating rules for the 3.5 GHz band should protect incumbents without driving away investment due to excessive regulatory restrictions or complexity. To achieve this balance, Google suggests that the FCC establish rules that: (1) ensure the widest possible market for new products and services by establishing reasonable technical specifications for commercial operations in the band, (2) allow small cell operations in the adjacent 3650-3700 MHz band, (3) reduce the size of exclusion zones to reflect the decreased risk of interference from small cell operations and calculate exclusion zone sizes based on the risk of interference to incumbent operations rather than the risk of interference to new entrants, and (4) permit outdoor operations.

A. Technical Specifications for Operations in the 3.5 GHz Band Should Promote Increased Capacity and Maximize Usability.

The Commission seeks comment on various technical characteristics of small cell operations.²⁰ Commission rules should require the SAS to set transmit power limits depending on the environment encountered, with the goal of maximizing service while protecting incumbent operations. Google anticipates that many secondary exclusive systems will use a cellular protocol such as LTE. For these systems, base stations tightly control the transmit power of mobile devices, and the use of small cells with limited operational radii will result in mobile device transmissions at very low power—typically under 23 dBm. For GAA devices utilizing protocols such as Wi-Fi, where tight power control is absent, Google similarly anticipates that a maximum power of 23 dBm will be sufficient. For fixed stations, the Commission should authorize a 36 dBm outdoor power limit, in line with the rules for Wi-Fi equipment, rather than

²⁰ *Id.* ¶¶ 129-143.

the 30 dBm EIRP proposed in the NPRM.²¹ As discussed above, permitting network deployments with these power limits in areas where they will not interfere with incumbent operations will enable both robust wireless network coverage and high spectral reuse of 3.5 GHz spectrum.

Moreover, as the Commission recognizes, there are numerous other mitigation techniques that can be used to avoid interference.²² For example, fast power control technology has been a mainstay of modern cellular technologies. Similarly, sophisticated channel coding/forward error correction, adaptive modulation, and MIMO techniques are mainstream features in both cellular and Wi-Fi technologies today. Technologies deployed for commercial use in the 3.5 GHz band will incorporate many of these established techniques, and manufacturers and operators have strong incentives to incorporate new techniques as they become available. But the FCC should not mandate any specific technique, because such a specified technique could soon become obsolete.

Finally, Google agrees with the Commission that devices should have the capability to switch to other authorized spectrum if necessary to avoid harmful interference to users in a higher tier. For example, FCC rules should require secondary exclusive users to vacate a band if doing so is necessary to accommodate incumbent access operations.²³

²¹ See *id.* ¶ 131.

²² *Id.* ¶ 152.

²³ *Id.*

B. The 3.5 GHz Rules Should Apply to Operations in the 3650-3700 MHz Band.

The Commission should include the 3650-3700 MHz band in its proposal for 3.5 GHz commercial operations.²⁴ This supplemental proposal will expand the utility of the 3.5 GHz band by providing up to 150 MHz of contiguous spectrum. As the Commission has recognized, the benefits of access to an additional 50 MHz of spectrum are significant.²⁵ More contiguous spectrum can support more uses, attract more users, and expand the equipment market—which will, in turn, will expand potential applications for the band.²⁶ The Commission should also verify and then grandfather existing commercial operations in the 3650-3700 MHz band for a period of time. At the end of this period, the FCC should convert these operations into secondary exclusive use subject to the SAS.

C. Dynamic Exclusion Zones Based on Small Cell Device Operating Parameters Will Protect Incumbent Systems and Enable Robust Wireless Deployment.

The Commission seeks comment on the appropriate size of exclusion zones needed to ensure protection for incumbent operations.²⁷ The FCC should establish exclusion zones that reflect the limited range and power output of the small cell commercial operations that are appropriate for the secondary exclusive tier. Doing so will increase the utility of the 3.5 GHz band by enabling operations in areas that would otherwise be off limits to commercial service.

²⁴ See *id.* ¶ 77.

²⁵ *Id.* ¶ 80.

²⁶ *Id.*

²⁷ See *id.* ¶¶ 109-123 (citing NTIA, *An Assessment of Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands* (October 2010) (“NTIA Fast Track Report”)).

As the Commission noted, the exclusion zones recommended by NTIA in its Fast Track Report for shared use of the 3.5 GHz band would cover 60 percent of the U.S. population.²⁸ The Fast Track Report, however, assumed that commercial operations in the band would be operated using macrocells, which the Commission and PCAST both indicate would not allow the most efficient use of the band. The NPRM, in contrast, proposes allowing small cell commercial operations in the band rather than macrocell operations. Small cell operations are characterized by lower antenna heights and lower transmit power. These operations present a substantially reduced interference threat for federal incumbent radar systems,²⁹ thus rendering the NTIA-calculated exclusion zones inappropriate for the NPRM's proposed use. Accordingly, the PCAST Spectrum Report's finding that "small cell, low power use could allow for significant reduction or even elimination of the exclusion zones"³⁰ is correct.

Significantly, the Fast Track Report also set its proposed exclusion zones based on the assumption that they would be used to prevent interference *into commercial systems* from incumbent radar.³¹ The FCC should calculate exclusion zones only with the goal of preventing interference *into incumbent systems*. The SAS could estimate the potential interference risks for new entrants, allowing new entrants to determine for themselves if they are willing to tolerate the interference likely to be experienced in a certain geographic area. Declaring geographic areas off-limits to potential users based solely on the supposition that users would be unable to solve interference challenges is an inflexible approach that leaves no room for innovation.

²⁸ *Id.* ¶ 6.

²⁹ *Id.* ¶ 119.

³⁰ PCAST Spectrum Report at 51.

³¹ NTIA Fast Track Report at 1-6 and 1-7.

Furthermore, the Commission's exclusion-zone rules should explicitly permit non-federal entrants to use the 3.5 GHz band in an exclusion zone if the incumbent is not currently operating and therefore does not need protection. There is no reason to exclude new operations if there are no incumbent operations to protect. However, the FCC should require secondary exclusive operations to cease in appropriate exclusion zone areas when incumbent systems notify the database that they will be operating.

D. Rules for 3.5 GHz Band Devices Should Reflect the Decreased Risk of Interference to Incumbents Presented by Small Cells by Permitting Outdoor Operations.

In addition to limiting exclusion zones as discussed above, other portions of the Commission's operating rules should recognize the reduced interference risk presented by small cell operations. Most importantly, the FCC should allow outdoor use of the 3.5 GHz band in all locations where there is no risk of interfering with incumbent operations.³²

As the Commission recognizes, the small cell use expected in the 3.5 GHz band will limit the geographic range of applications operating in the band,³³ raising practical challenges for both consumers and investors. Further limiting use of the band to indoor operations would render the band substantially unusable for companies seeking to deploy systems using a cellular-based architecture, or for wide-area networks such as the Wi-Fi networks offered throughout many cities by cable operators. Such a restriction would greatly reduce the market for 3.5 GHz technologies, possibly making the band unattractive for equipment manufacturers who must achieve scale to support the huge costs involved in creating a new class of equipment and components.

³² See NPRM ¶ 150 (seeking comment on outdoor operations).

³³ See, e.g., *id.* ¶ 4.

IV. A ROBUST SPECTRUM ACCESS SYSTEM WILL PROTECT INCUMBENT USERS AND IMPROVE SPECTRAL EFFICIENCY IN THE 3.5 GHz BAND.

The Commission notes that existing database technologies can be used to assign frequencies dynamically and mitigate interference in bands where incumbent uses are geographically known.³⁴ The 3.5 GHz band, which is characterized by “highly localized”³⁵ uses that include geographically limited incumbent federal users and grandfathered earth stations in the Fixed Satellite Service,³⁶ is a perfect candidate for such technologies.

The TV White Spaces database system provides the Commission with useful experience on which to draw in developing an SAS that will maximize the utility of the 3.5 GHz band. As the Commission recognizes, however, implementing the 3.5 GHz Spectrum Access System will require a “new iteration of database technology.”³⁷ In addition to baseline standards developed for TV White Spaces database technologies, the Commission should demand additional functionality tailored to spectrum sharing in the 3.5 GHz band.

³⁴ *Id.* ¶ 95. For example, the TV White Spaces database implementation shows that database technology “can be used to achieve dynamic frequency assignment while mitigating interference between devices in the same frequency band.” *Id.*; see also *Unlicensed Operation in the TV Broadcast Bands, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd. 16807 (2008) ¶ 72 (“White Spaces Second Report and Order”). TV White Spaces databases include exclusion zones to protect incumbent operations and registration of authorized systems, as well as up-to-date information regarding incumbent operating locations and a mechanism to update the database within a reasonable period of time after incumbent operations start or stop at a particular location. See 47 C.F.R. § 15 Subpart H.

³⁵ NPRM ¶ 5; see also *id.* ¶ 19.

³⁶ NTIA Fast Track Report at 2-5 to 2-6; NPRM App. A. Most high-power operations are located on ships and aircraft with some coastal operations. NTIA Fast Track Report at vi. Many of the remaining operations are limited to military and other training facilities. *Id.* at vi, 1-7, 3-30 to 3-33.

³⁷ NPRM ¶ 95.

First, the Commission should ensure that the 3.5 GHz SAS requires at least the same level of accuracy as the databases used by TV White Spaces devices. Access to specific geographical information about current uses of the band will allow commercial users to avoid causing harmful interference to incumbents, while readily identifying spectrum where their own devices can operate.

Second, the FCC should require only some types of devices to include standalone geolocation capability.³⁸ Users in the secondary exclusive tier that will provide quality-of-service-dependent operations are likely to use air interfaces such as LTE, which have built-in safeguards that ensure mobile terminals transmit only when authenticated by a base station and at a power level controlled by the base station. These mobile terminals therefore do not need their own geolocation capability.

Third, the Commission should implement an SAS functionality allowing mutual protection among secondary exclusive users in a manner that maximizes the spectral efficiency and utilization of the band.³⁹ To accomplish this goal, the Commission's rules should incorporate several concepts outlined in the PCAST Spectrum Report, including characterization of the interference environment, implementation of usage metrics, and deconfliction and resolution of interference issues.⁴⁰ These features will promote sharing of all available spectrum,

³⁸ See, e.g., 47 C.F.R. § 15.703(e) (permitting “Mode 1” client White Spaces devices to operate under the control of master devices equipped with geolocation technologies).

³⁹ See NPRM ¶ 97 (seeking comment on database characteristics).

⁴⁰ PCAST Spectrum Report at 84 table 7.1; see also *id.* at 26-27, App. C.

minimize the risk of interference to incumbent systems, and give equipment designers and manufacturers a set of guidelines that can inform long-term investment in wireless technology.⁴¹

Fourth, as with TV White Spaces databases, commercial interests should administer the 3.5 GHz SAS.⁴² The private sector will develop mechanisms to maximize commercial viability of shared spectrum through the SAS, including: (1) a highly secure interface to allow federal entities to manage Incumbent Access geographical zones confidentially (*i.e.*, without revealing details about the nature and precise location of sensitive federal communications systems), and (2) a secure public interface for use by commercial entities. To provide additional protection against warehousing spectrum, data about secondary exclusive authorizations in the SAS should be transparent and publicly available for audit by third parties. Moreover, the precise calculations and algorithms used by the SAS must be published and standardized to support a system that will include multiple SAS systems and administrators. To the extent that multiple parties are interested in SAS administration, the Commission should establish a process that will allow interested parties to work with the Office of Engineering and Technology to design standards for the SAS database administration, similar to the process that occurred in the TV White Spaces proceeding.⁴³

⁴¹ Mutual protection for secondary exclusive uses could be achieved through very basic geographic or spectral separation. However, interference avoidance algorithms that also incorporate detailed knowledge of infrastructure element locations, terrain calculations, and modern self-organizing network mechanisms such as network-listen technologies and mobile-based measurements will enable the same spectrum to accommodate more users and uses, maximizing the utility of the band.

⁴² NPRM ¶ 98 (seeking comment on database administration).

⁴³ See White Spaces Second Report and Order ¶ 107; 47 C.F.R. § 0.241.

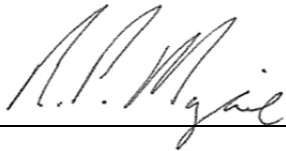
Fifth, and finally, the Commission should require a “hardware lock” to restrict device operation to the parameters approved by the SAS.⁴⁴ Existing commercial small cell deployments have developed solutions to address the concern that devices could operate in an unauthorized manner, and these solutions could be deployed in the 3.5 GHz band. For example, vendors have adopted Trusted Platform Modules (“TPMs”) in femtocells to prevent unauthorized operation, either by unauthenticated users or in unapproved locations. Similar technologies could be deployed in the 3.5 GHz band to enforce a “hardware lock” on the communications chain in devices, making them highly tamper-proof.

⁴⁴ See NPRM ¶ 100 (seeking comment on enforcement mechanisms for devices that operate outside SAS-authorized parameters).

V. CONCLUSION.

Shared spectrum access in the 3.5 GHz band has the potential to help ease the current “spectrum crunch,” expand access to wireless broadband, and serve as a model for successful shared access in other federally allocated bands. Adopting the recommendations described above will maximize utility of the band and encourage sustained investment while preventing harmful interference to incumbent operations.

Respectfully submitted,



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February 20, 2013

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